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Development of a lubricity test for urinary biomaterials

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Materials commonly used as urinary tract prostheses include polyurethane (PU) and silicone. An important property of a urinary device is the ease with which it can be inserted and then removed after it has performed its required function. Friction between a catheter and mucosa can damage the urethra. This paper describes a method to comparatively evaluate the lubricity of urinary biomaterials using a texture analyser in tensile mode and agar, to simulate the moist environment of urinary tract mucosa (Marmieri et al. 1996).

Biomaterial lubricity was performed by initially allowing the biomaterial to equilibrate in the agar for a specified time, prior to vertical removal using the texture analyser in tensile mode. The resulting area under the force-distance curve gives a value of Work Done (Nmm). Increased values of work are indicative of decreased biomaterial lubricity.

The surface roughness of the materials tested was examined using atomic force microscopy (AFM) as previously reported (McGovern et al. 1997). Advancing and receding contact angles of each material were determined using a dynamic contact angle analyser (McGovern et al. 1997).

The materials tested were all silicone-based (first six materials in the table), PU-based (materials seven to ten from table) or PEO/PU copolymer-based (last two materials). Results were statistically analysed using one-way analysis of variance, $p<0.05$ showing significance. Correlation plots were drawn of slipperiness against surface roughness and advancing contact angle.

The results of the lubricity test, AFM and Contact angle analyses are shown in table 1. In this, standard deviations are not shown to retain clarity, however, the c.v. in all cases was less than 5%. From the correlation plots, the correlation coefficients, r, were calculated and were as follows; r=0.475 for lubricity and surface roughness, 0.568 for lubricity and advancing contact angle.

Table 1. Lubricity (work done), surface roughness (Rq) and advancing contact angles (C. Angle) of biomaterials

Material	Work (Nmm)	Rq (nm)	C. Angle (^{0})
Per-q-cath	15.47	45.88	100.23
Barium silicone	14.20	41.79	109.56
Bis trioxide	18.03	81.79	107.85
V-cath	18.27	57.38	97.22
Bis. 4070 sub.	15.17	57.29	111.91
Bis. 4765 sub.	17.52	59.20	108.88
Picc shield	14.97	5.72	61.43
L-cath	21.21	62.92	63.07
Teco. barium	21.59	72.06	70.09
Teco. bismuth	14.43	117.59	78.30
Centermark	24.59	98.89	59.83
Landmark	21.35	140.12	74.36

Significant differences were seen between the work required to remove the different materials from the agar. From the r values, it can be stated that there is no correlation between the lubricity and surface roughness or contact angles, however, this may have been a consequence of the relatively small number of materials examined. The lower work done values seen with the more hydrophilic materials may be due to these materials imbibing water as they reside in the agar before testing, and hence increasing lubricity (Ikada et al., 1993).

In general, the silicone based materials, were smoother, more hydrophilic and more slippery than the other materials tested. From these results, although silicone may be easier to insert than the other materials, further testing should be performed to elucidate which material would be easiest to insert but also rigid enough to retain its position in the urinary tract. This slipperiness test, coupled with other surface and bulk analyses, could be used to screen novel materials for their suitability as urinary devices inducing minimal pain on insertion and tissue trauma.

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